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WATER AND RELATED LAND RESOURCES INVESTIGATION
PAWCATUCK RIVER AND
NARRAGANSETT BAY DRAINAGE BASINS

**PAWTUXET RIVER WATERSHED
INTERIM REPORT**

Information Pamphlet



OCTOBER 1976

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

INTRODUCTION

Although the Pawtuxet River in Rhode Island has a recorded history of flooding which dates back to the early 1800's, relatively little damage to development has occurred. Until recent years, the area has been mostly rural, with little development existing in the path of the flood waters.

Within the last decade, however, urban development has increasingly spread out from the central city of Providence. This movement has been assisted by a growing network of highways which creates easy access to relatively inexpensive but flood-prone land for residential, commercial, and industrial development.

The most recent flood -- in March, 1968 -- although causing minimal damage, alerted residents to the potential flood hazards which have been created by this spreading urban development. It also focused attention on the lack of flood proofing of most structures which have been built in the flood plain.

With development expected to spread throughout the basin and create an urban runoff impact upon existing structures along the main stem, it became apparent that a plan to protect this growing commitment of financial and human resources was required. This study is the outgrowth of that perceived need.

THE STUDY REPORT

This report examines flooding and related water resource problems in the Pawtuxet River basin. It reviews possible solutions in terms of costs and benefits. It assesses their impacts on the physical environment, the economy, and the lives of the people who live and work in the area. And it proposes a course of action that is believed to be both cost efficient and least disruptive.

The Pawtuxet Study is the first of five major watershed studies which make up the Pawcatuck River and Narragansett Bay Drainage Basins (PNB) Study. The other basins consist of the Providence (including the Blackstone) to the north, the Pawcatuck to the southwest, Narragansett Bay local drainage to the southeast, and the Taunton (which is not adjoining) off the northeast. These studies are being conducted by the New England Division, U. S. Army Corps of Engineers, in compliance with resolutions adopted by the Committees on Public Works of the United States Senate and House of Representatives in 1968 and 1970.

During the course of this study, numerous formal and informal meetings were held with appropriate Federal and State government agencies, with public officials and private interests in the towns and cities in which the basin lies, in order to coordinate study proposals with the plans and goals of these diverse interests.

Four public meetings were held in May, 1969, in Taunton and Uxbridge, Massachusetts, and Providence and Kingston, Rhode Island, to solicit people's views prior to the start of the study. During the inventory and analysis phases of the study, over 60 informal meetings were held, mostly within the basin, with State, municipal and local interests. Two plan formulation meetings were held in May, 1975, in Warwick and Cranston, Rhode Island, to present study findings and alternative solutions, and obtain people's views about which solution would be more desirable, so that the solution proposed would reflect the desires of at least a majority of those citizens affected. In addition to subsequent contacts with Federal agencies, approximately 100 field contacts, 20 informal contacts with State and municipal interests, and several informal meetings with citizen groups were made. And now, a late stage public meeting is being held as follows:

WARWICK CITY HALL
CITY COUNCIL CHAMBERS
3275 Post Road
Warwick (Apponaug), Rhode Island
14 October 1976, 7:30 P.M.

The report, of which this pamphlet is a brief summary, consists of these parts:

A Main Report written in nontechnical language which describes the area under study as it presently exists; its problems and needs with regard to flooding and related water resources; proposed solutions with their economic costs, benefits and justification; and recommendations for carrying out the proposed plan, including division of responsibility between Federal and non-Federal interests.

A Technical Report providing complete technical detail on the conduct, findings, and proposed solutions of the study; and incorporates geologic and hydrologic data previously compiled as Planning Aid Reports.

A Draft Environmental Impact Statement that discusses the results of special studies concerning the environmental impacts of the proposed action, alternative actions and no-action measures.

PRIOR STUDIES

This study draws from a number of previous studies conducted between 1928 and the present, including several still in progress. These studies deal with problems of flood control, water supply, water quality, streamflow regulation, hydroelectric power, navigation, pollution control, shore erosion, fish and wildlife, recreation, historic site preservation, land management, mineral production, insect control, hurricane damage, and flood insurance.

THE PAWTUXET RIVER BASIN

The Pawtuxet, as shown by the map in Plate 1, consists of two principal branches which combine to form the 10.9-mile long main stem. The North Branch rises in hilly uplands near the Connecticut border and flows generally southeasterly through Providence and Kent Counties toward Narragansett Bay. The South Branch originates in slightly lower uplands of Kent and northern Washington Counties and its headwater streams converge to flow generally northeasterly to join the North Branch in West Warwick. The main stem in West Warwick, Warwick and Cranston is augmented by several small streams, that enter principally from the north, before discharging into Pawtuxet Cove on the tidal Providence River. During coastal storms, tides may overtop the dam at the head of Pawtuxet Cove and reach over four miles up the main stem beyond the mouth of the tributary Pocasset River.

The watershed formed by this system and its tributaries encompasses a pie shaped area of 230 square miles lying entirely in west-central Rhode Island and pointing eastward toward Narragansett Bay.

Although most of the larger streams of the watershed are highly developed with industrial water supply reservoirs and power dams, plus several public water supply reservoirs -- the largest being Scituate Reservoir -- only the lower, eastern third contains highly urbanized residential, commercial and industrial areas. Suburban residential development is pushing westward as the forerunner of expansion of the Providence metropolitan area.

The upper reaches of the North and South Branches are clean enough for swimming and drinking. Most of the main stem has limited use and near its mouth can be used only for industrial purposes. Three municipal, one State and one industrial sewage treatment plants discharge their treated effluent into the main stem, and another is under consideration for the South Branch at Coventry. However, frequent occurrence of low flow conditions contribute at times to high pollutorial loadings.

WHERE FLOOD IMPACT WOULD HIT

The three communities that would experience the primary impact of a flood are Warwick, Cranston and West Warwick, where significant portions of the flood plain of the main stem have been developed with homes, businesses and industries. These suburban communities have been growing very rapidly in the years since 1950, while the central city of Providence has lost significant population, and may well become central cities in future years. Two massive shopping centers, as well as numerous manufacturing and service industries have located within the main stem flood plain. Altogether along the 11 miles of the main stem, 471 structures are susceptible to flood losses from a 100-year flood. (A 100-year flood is one having a one percent chance of occurrence in any given year. It is based on statistical analysis of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the watershed and nearby region).

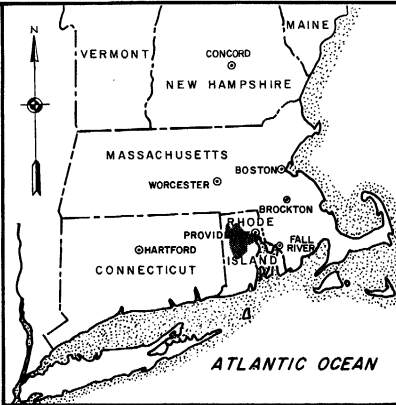
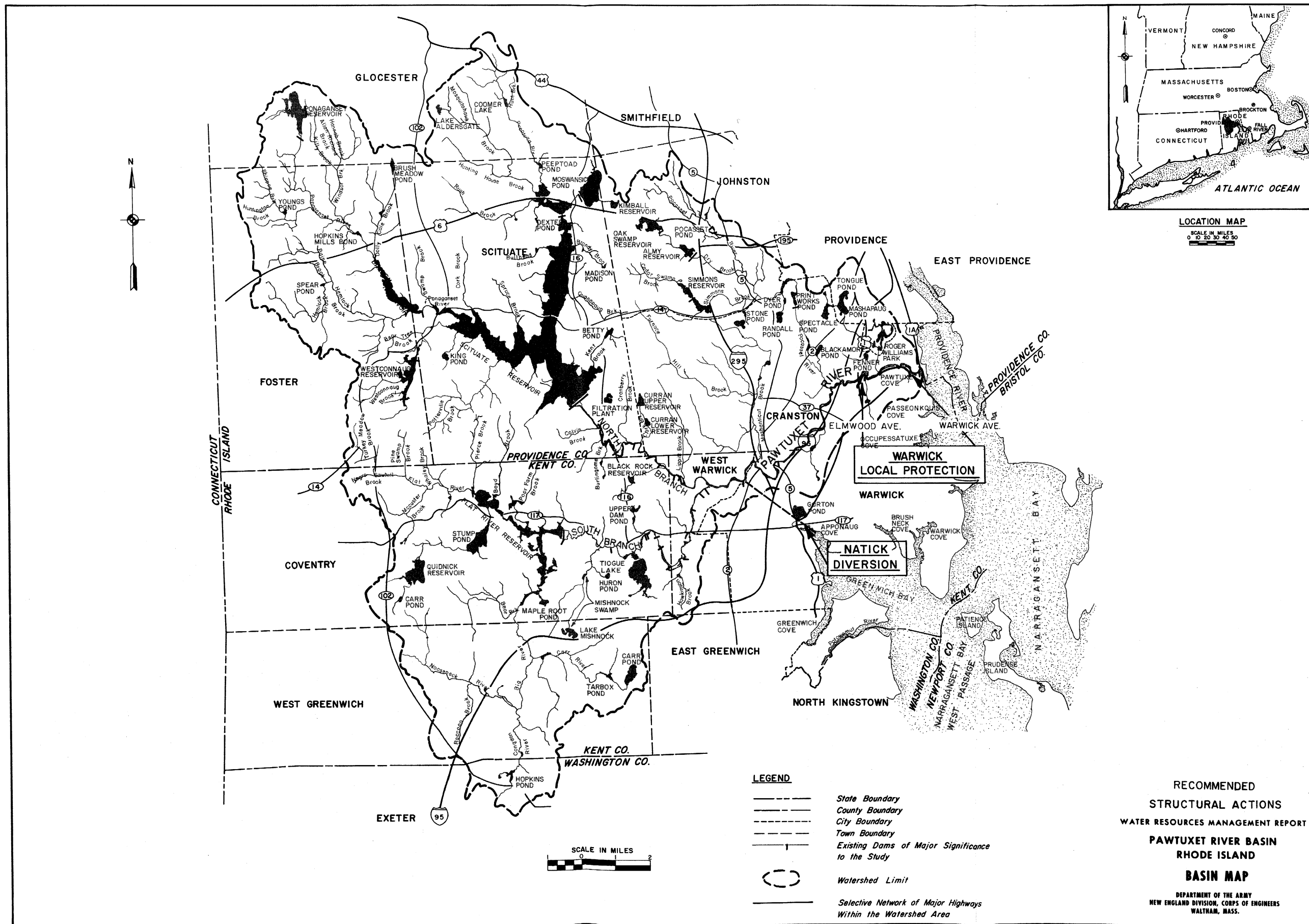
An additional 1,385 structures (or a total of 1,856 structures) are susceptible to flood losses at the Standard Project Flood (SPF) level. (The Standard Project Flood represents the flood discharge or flood stage level that may be expected from the most severe combination of meteorological and hydrologic conditions that are considered to be reasonably characteristic of the region, excluding extremely rare combinations).

Although the Pawtuxet basin has yet to be affected by a high-damage flood, there is tremendous potential for the area to experience substantial monetary losses in the event of major flooding - in excess of \$180 million at the SPF event.

A FLOOD MANAGEMENT PLAN FOR THE PAWTUXET

In preparing a plan for the flood management needs of the basin, potential flood problems throughout the basin were surveyed and a number of alternative solutions were examined. In evaluating each one, these general criteria were used:

1. The proposal must provide tangible benefits that exceed the economic costs to implement the proposal, and it must be a cost effective way to accomplish that purpose.
2. It must be feasible to implement and local protection works for an urban area should provide protection to Standard Project Flood water levels (previously defined).



- LEGEND**
- State Boundary
 - County Boundary
 - City Boundary
 - Town Boundary
 - Existing Dams of Major Significance to the Study
 - () Watershed Limit
 - Selective Network of Major Highways Within the Watershed Area

RECOMMENDED
STRUCTURAL ACTIONS
WATER RESOURCES MANAGEMENT REPORT
**PAWTUXET RIVER BASIN
RHODE ISLAND
BASIN MAP**
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

3. It must address the environmental and social requirements of the National Environmental Policy Act of 1969, and other appropriate regulations. An Environmental Impact Statement accompanies the Main Report.

Most of the actions considered failed to meet one or more of these criteria. A number of flood-prone areas were not found to be highly enough developed to warrant the cost of their protection. Along the main stem of the Pawtuxet, however, and in one highly developed flood-prone area in particular -- the Elmwood Avenue-Warwick Avenue section of Warwick -- a plan of protection does meet all of the criteria. The selected plan, which provides for a combination of regulatory, corrective and future action measures, is shown on Plate 2 following the text section.

The plan calls for the construction of two projects: the Natick Diversion tunnel to reroute flood waters from the upper part of the main stem directly into Apponaug Cove and Greenwich Bay; and a Local Protection Project, consisting of a series of dikes and walls to prevent the river from overflowing its banks and flooding the highly developed Elmwood Avenue-Warwick Avenue section of Warwick.

These two projects would work in concert. When the river approaches flood level, the tunnel would begin to divert flood waters away from the main stem, thus lowering the maximum flood stage that otherwise would occur throughout the lower river reaches. This lowered level of flood waters, although subject during major coastal storms to tidal flooding moving up the river from Narragansett Bay, would be prevented from reaching the area protected by the walls and dikes. Thus, the local protection works need not be as high, or as expensive, as they otherwise would if the diversion were not constructed. However, because of this tidal effect, the reduction due to the diversion would not be as great in the immediate vicinity of the local protection sites as in other river reaches such as upstream of the Pontiac Dam.

In addition to these two structural or corrective measures, the plan also contains the following regulatory and future action measures:

- All of the local communities involved (Warwick, Cranston and West Warwick, and preferably all of the basin communities) would be required to participate in the National Flood Insurance Program, a Federal program which provides flood insurance at low, subsidized rates for owners, and in return requires communities to adopt certain zoning regulations in flood-prone areas. These communities would also be encouraged to enact other regulatory measures for their flood plains.

- A Future Action Program would involve management of the existing Scituate Reservoir on the North Branch, and the proposed Big River Reservoir on the South Branch, in such a way as to maximize the flood water storage capability of these two reservoirs, without impairing their primary roles as water supply sources for the region.

PUTTING THE PLAN INTO OPERATION

If this plan is approved by State and Federal officials, and by the communities involved, it would take about two years to design and about four years to construct. Realistically, the proposal would probably not be in operation much before 1985.

The total cost of implementation, including acquiring the necessary land and easements, and building the Natick Diversion and the Local Protection Project, is \$59,300,000. Of this total amount, the Federal government would pay \$58,500,000, and the City of Warwick -- which would benefit directly and exclusively from the Local Protection Project -- would contribute \$800,000. If the local share were spread over 20 years, this cost would amount to annual interest and amortization charges of about \$80,000.

In addition, the City of Warwick would be required to pay operation, maintenance and major replacement costs of the Local Protection Project, amounting to about \$17,000 per year. The total costs of the Natick Diversion, including operation and maintenance, would be borne by the Federal Government. These costs are summarized in Table 1.

BENEFITS OF THE PLAN

The major economic benefit of the plan would be a significant reduction in flood damages sustained along the main stem of the Pawtuxet, and essentially complete elimination of potential damages in the Elmwood Avenue-Warwick Avenue area of Warwick, in the event of a flood. Based on the 1972 level of development there, the damages that would be sustained in a Standard Project Flood -- expressed on an annual basis -- would be about \$1,355,000 per year. Once the project was completed, however, these damages would be reduced to only \$173,000 per year, a reduction of \$1,181,900, or 87 percent. Furthermore, as the value of the protected development increases in the future, damage reduction will be even more significant. Based on a 100-year life, the project would reduce annual flood damages during the years between 1985 and 2085 from \$1,381,500 to \$69,400, a reduction of \$1,312,100, or 95 percent.

TABLE 1

TOTAL PROJECT INVESTMENT AND ANNUAL CHARGES

	<u>Federal</u>			<u>Non-Federal</u>	
	<u>Natick Diversion</u>	<u>Warwick L. P. P.</u>	<u>Total Federal</u>	<u>Total Warwick L. P. P.</u>	<u>Total</u>
Construction Costs	\$48,630,000	\$ 9,550,000	\$58,180,000	\$ -	\$58,180,000
Lands and Damages	<u>320,000</u> 48,950,000	<u>-</u> 9,550,000	<u>320,000</u> 58,500,000	<u>800,000</u> 800,000	<u>1,120,000</u> 59,300,000
Interest During Construction	<u>6,000,000</u> \$54,950,000	<u>880,000</u> \$10,430,000	<u>6,880,000</u> \$65,380,000	<u>80,000</u> \$880,000	<u>6,960,000</u> \$66,260,000
<u>ANNUAL CHARGES</u>					
Interest and Amortization	3,374,400	640,500	4,014,900	79,900	4,094,800
Operation and Maintenance	95,000	-	95,000	12,000	107,000
Major Replacements	1,000	-	1,000	4,900	5,900
Loss of Taxes on Lands	<u>700</u> \$ 3,471,100	<u>-</u> \$ 640,500	<u>700</u> \$ 4,111,600	<u>2,700</u> \$ 99,500	<u>3,400</u> \$ 4,211,100
TOTALS (Rounded to)	\$ 3,471,000	\$ 641,000	\$ 4,112,000	\$ 99,000	\$ 4,211,000

Other economic benefits of the plan include:

- availability of about 200 acres of presently undevelopable land located within the floodway of the main stem which could be developed for industrial, commercial and residential purposes once the project is completed. This annual benefit is estimated at \$717,000 per year.

- protection of three municipal, a State institution and an industrial sewage treatment plants located downstream of the Natick Diversion, together with any future expansion of these facilities.

- increased employment during the four-year construction phase. It is estimated that the wages portion of the project total cost would be about \$17,500,000. As 80 percent of the labor would be hired locally, many jobs would be created in a region whose current unemployment rate is 10.6 percent.

- reduced flood insurance premiums under the National Flood Insurance Program.

- increased economic vitality of the region as a whole and the area of protection in particular, as new businesses may benefit from locating in the protected area and existing businesses expand and modernize as a result of the substantial removal of catastrophic flood damage threats to the area.

ENVIRONMENTAL AND SOCIAL EFFECTS

In general, there are no long-term adverse environmental or social impacts on the region as a result of the plan. The following effects of the plan are of a temporary nature:

Marine Impacts and Wildlife - Contingent upon the diversion's flow rate and duration, diversion of fresh water from the Pawtuxet River into Apponaug Cove and Greenwich Bay could reduce the salinities of these salt water bodies and cause stress on their marine life. The actual effect of reduced salinity on clams and bottom dwellers is not certain due to many variables. Some commercial shellfishing flats in Greenwich Bay could be closed due to the presence of total coliform bacteria. At a major diversion rate expected to occur once every 15 years, adult species in Apponaug Cove would begin to be harmed due to reduced salinity, whereas early life stages could be destroyed.

A total land requirement of about 40 acres would be necessary for the construction of the local protection project, including six acres of vegetated land that would be lost by the elimination of an oxbow in the river. Where possible, a 20-foot buffer zone would be left between the dikes or walls and the water's edge, which would help to re-establish any vegetational or animal life that is displaced during construction activities. The impact of the project on freshwater species would be negligible.

Water Quality - Pollution of the Pawtuxet would not be increased as a result of the plan. However, protection of the five sewage treatment plants and prevention of potential septic tank overflows in the protected area could reduce potential water pollution.

Noise and Air Pollution - This would increase temporarily during construction, as a result of increased truck traffic and other activities associated with construction. This could have an adverse impact on merchants and residents in the local protection area, but it would be a temporary condition.

Land Use - Forty-three acres of land, including seven homes, would need to be acquired for the project. In addition, permanent easements for the tunnel right-of-way would have to be secured under 50 parcels, involving two commercial, six residential, and four public buildings. Also, temporary easements on 11 acres would be required during construction. The tunnel poses absolutely no threat to the surface of the land under which it would be constructed. The purchase of seven homes would be required to allow for construction of the Natick Diversion and Local Protection Projects. Five acres of land would also be reclaimed as a result of the elimination of an oxbow at the Local Protection Project site.

Aesthetic Impacts - Structural elements of the proposed plan such as dikes, walls, the new regulating dam at the river intake works, and an operation and maintenance structure at the diversion tunnel outlet may be construed by some as having negative visual appeal. Aesthetic enhancement measures including new plantings and site planning techniques would be employed in conjunction with these project components to insure that they are visually compatible with their surroundings.

Cultural and Historical Resources - These would not be affected by the project. The marsh areas of Gorton Pond would not be affected by the tunnel nor would it have impact on the Natick Mill Village District or the Westcott Mill Housing District. Some damage could occur to the floor of Apponaug Cove, and an underwater survey of that area is planned to determine these potential impacts.

Recreational Resources - These would not be affected, although previously inundated lands which are best held for low intensity recreation and conservation purposes may come under development pressures. There could be a sightseeing area overlooking the intake structure of the diversion, and recreational facilities such as walkways, bikeways, benches, small fishing piers, and picnic tables would be considered in the advance design stages of the Local Protection Project.

A detailed analysis of the environmental and social impacts of the plan is contained in the Draft Environmental Impact Statement, which accompanies the Main Report.

Single copies of the Draft Environmental Impact Statement will be available from the Division Engineer, New England Division, Corps of Engineers, 424 Trapelo Road, Waltham, Massachusetts 02154, fifteen (15) days prior to the public meeting. Also, reference copies will be available for review at the Waltham office.

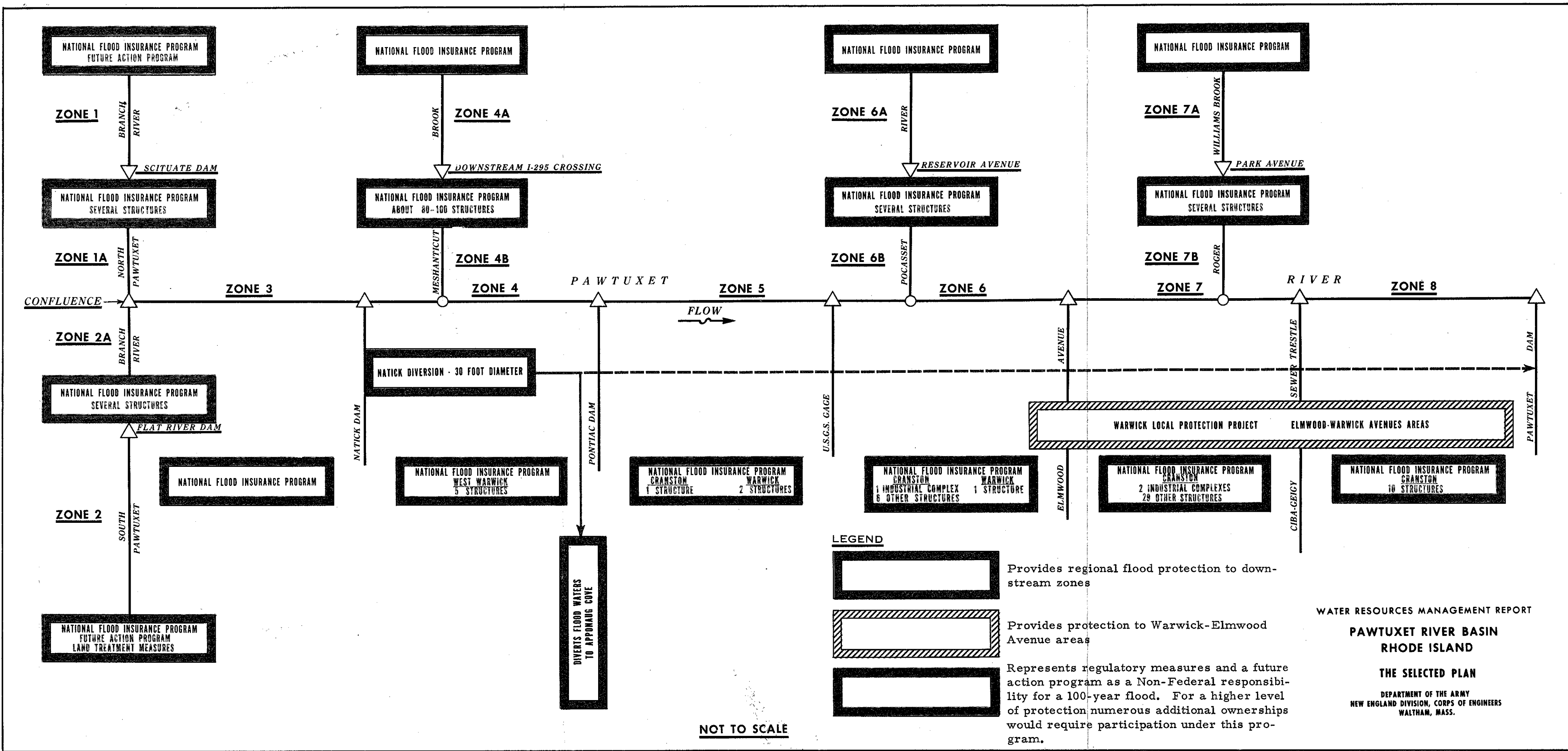
THE SELECTED PLAN

CAPTION

1. All of the communities involved in the plan and preferably all of the basin communities would be required to participate in the National Flood Insurance Program and adopt certain zoning regulations and other measures designed to reduce the likelihood of new development occurring in the flood plains of the Pawtuxet. Warwick and Cranston now operate under the provisions of the regular program, and property owners in those communities are eligible for low-cost flood insurance. Other communities operate under the provisions of the Emergency Flood Control Act and have not adopted the required zoning regulations.
2. It is recommended that a Future Action Program be instituted by the State of Rhode Island and local communities when the proposed Big River Reservoir is constructed on the South Branch of the Pawtuxet. This program would provide for the systematic operation of the Big River Reservoir and the existing Scituate Reservoir in such a way that each reservoir would have significant storage capacity at all times in the event of a flood, in order to reduce flood flows down river from those two major storage reservoirs. This would be accomplished in a way so as not to impair the primary use of the reservoirs as water supply sources. Local communities are further encouraged to adopt far-reaching land use plans and regulations for the flood-prone areas of the Pawtuxet and its tributaries, so that future development will not occur there.
3. A two-and-one-half mile diversionary tunnel would be constructed 100 feet underground to reroute flood waters of the Pawtuxet River from a point just below the existing Natick Dam directly into Apponaug Cove and Greenwich Bay. This diversion would operate only during flood conditions, and would substantially lower flood water levels throughout the lower ten miles of the main stem of the Pawtuxet, which is the most heavily urbanized section of the basin.
4. Dikes and walls would be constructed along the river in Warwick to protect the heavily-developed Elmwood Avenue-Warwick Avenue areas from riverine flood flows and from tidal flooding reaching up from Pawtuxet Cove at the mouth of the river, in times of abnormally high tides.

These two projects would virtually eliminate the possibility of flood damage in the Elmwood Avenue-Warwick Avenue areas and substantially reduce it along the rest of the 10-mile stretch of the main stem.



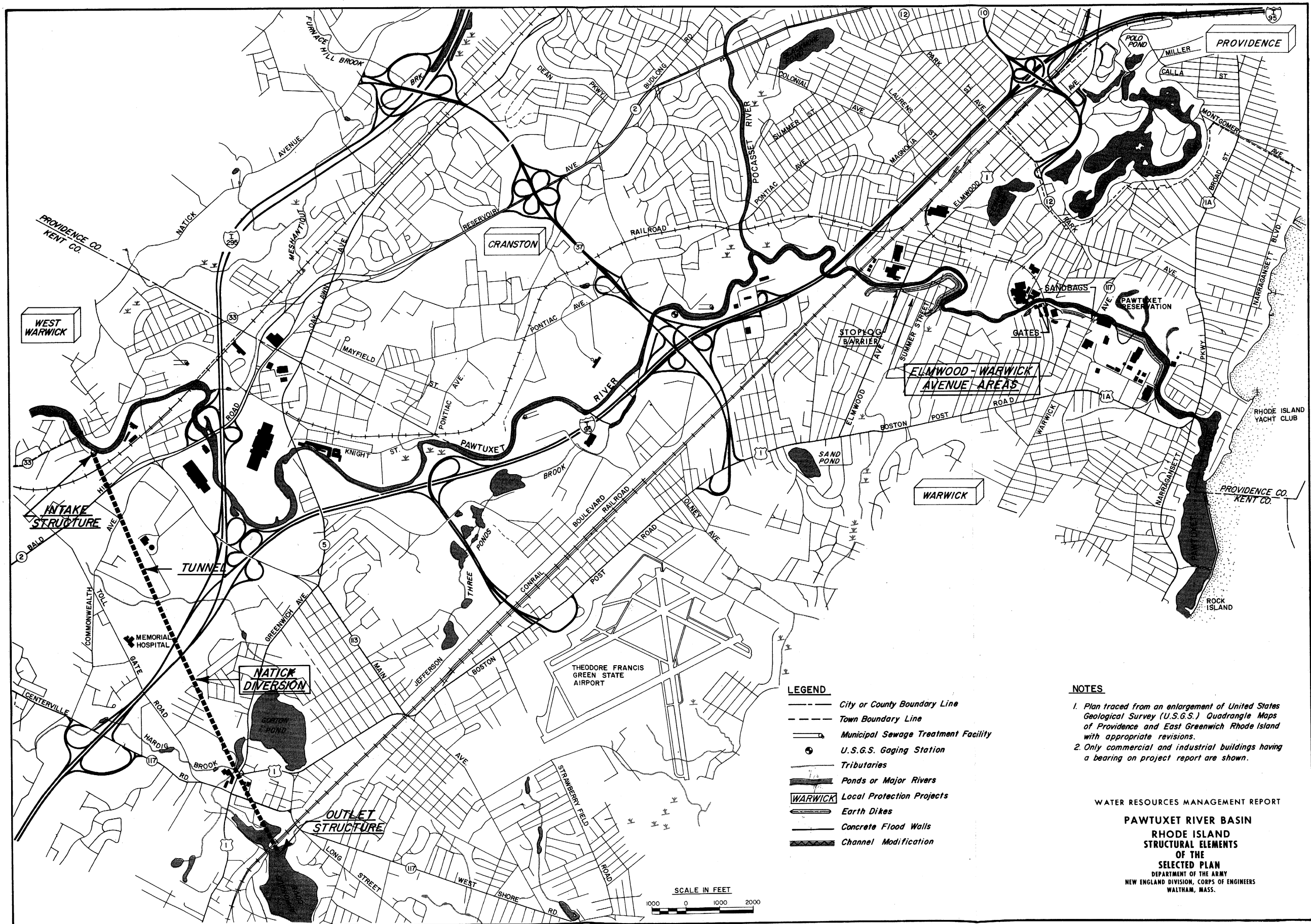


STRUCTURAL ELEMENTS OF THE SELECTED PLAN

CAPTION

This map shows the lower reach of the main stem of the Pawtuxet River, from Natick Dam, at the left, to Pawtuxet Cove (right) at the mouth of the river. The red broken line at lower left indicates the route of the Natick Diversion tunnel which would take flood waters from the Pawtuxet at the Intake Structure and divert it through a 30-foot diameter tunnel 100 feet or more underground, to an Outlet Structure, (bottom left), where the flood waters would be discharged directly into Apponaug Cove. The green and red lines along the river bank at upper right indicate respectively, the dikes and walls of the Warwick Local Protection Project, which would keep the reduced level of flood flows, as well as abnormally high tides, from topping the banks of the river and flooding the heavily-developed Elmwood Avenue-Warwick Avenue areas. The relationship of the structural elements of the plan to the basin was previously shown in Plate 1.





LEGEND

- City or County Boundary Line
- Town Boundary Line
- Municipal Sewage Treatment Facility
- U.S.G.S. Gaging Station
- Tributaries
- Ponds or Major Rivers
- Local Protection Projects
- Earth Dikes
- Concrete Flood Walls
- Channel Modification

NOTES

1. Plan traced from an enlargement of United States Geological Survey (U.S.G.S.) Quadrangle Maps of Providence and East Greenwich Rhode Island with appropriate revisions.
2. Only commercial and industrial buildings having a bearing on project report are shown.

WATER RESOURCES MANAGEMENT REPORT

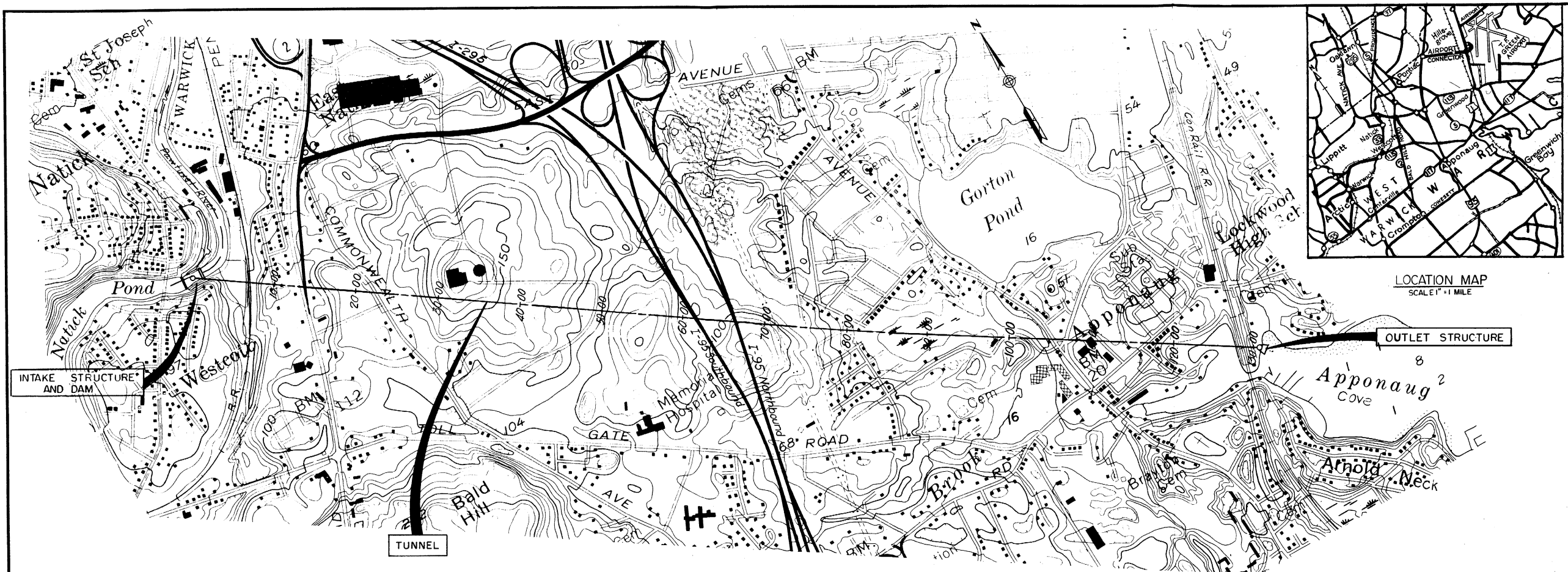
**PAWTUXET RIVER BASIN
RHODE ISLAND
STRUCTURAL ELEMENTS
OF THE
SELECTED PLAN
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.**

NA TICK DIVERSION

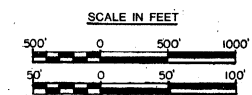
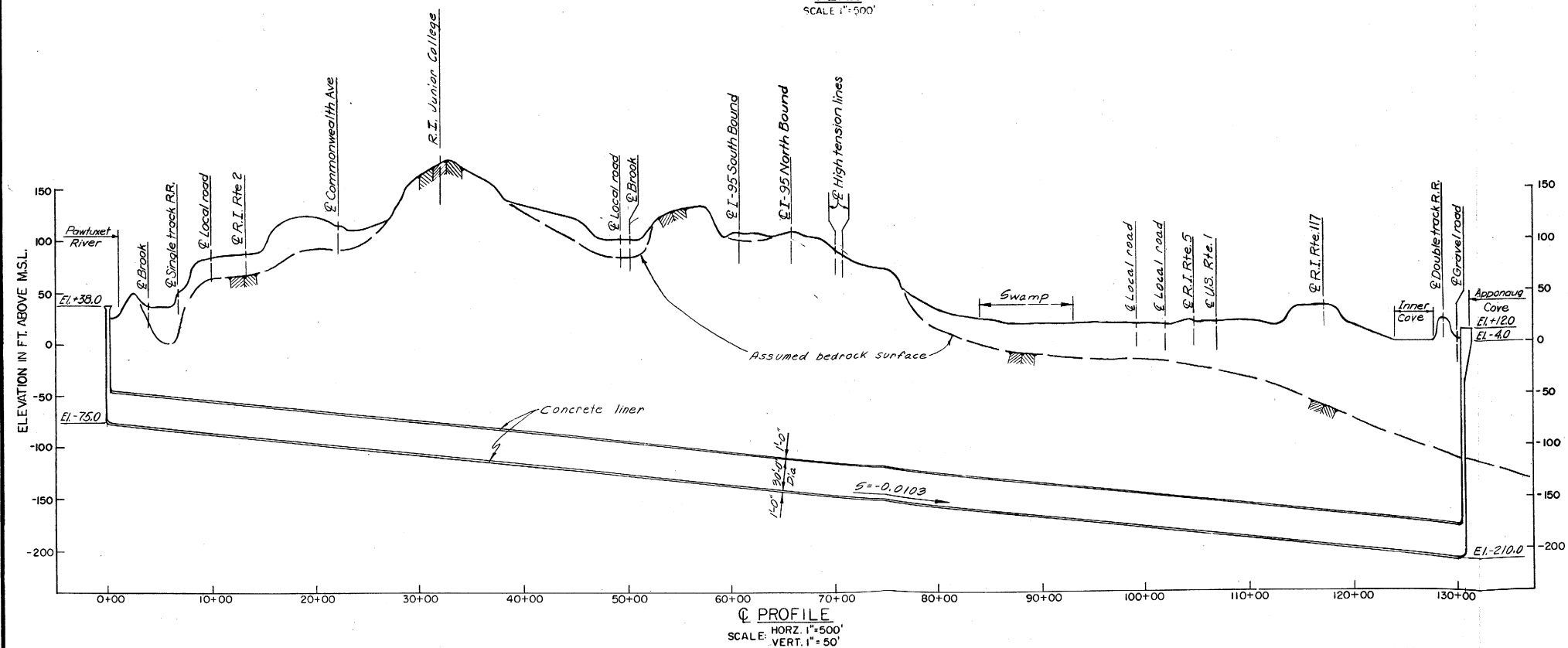
CAPTION

This map and profile of the Natick Diversion tunnel shows the detailed route of the 30-foot diameter tunnel that would divert flood waters of the Pawtuxet River directly into Apponaug Cove. The profile shows the depth of the tunnel underground for its entire two-and-one-half mile length. The two attached drawings following depict an artist's rendition of the Intake Works (left) which would be constructed in the river just below the Natick Dam, and the Outlet Works (right) where flood waters would be discharged into Apponaug Cove. During a flood condition, the rising waters of the Pawtuxet, controlled by the dam just downstream of the intake, would activate the Intake Works at a pre-arranged level and the diversion tunnel would begin to operate to reroute flood waters through the tunnel and discharge them through the Outlet Works into Apponaug Cove.

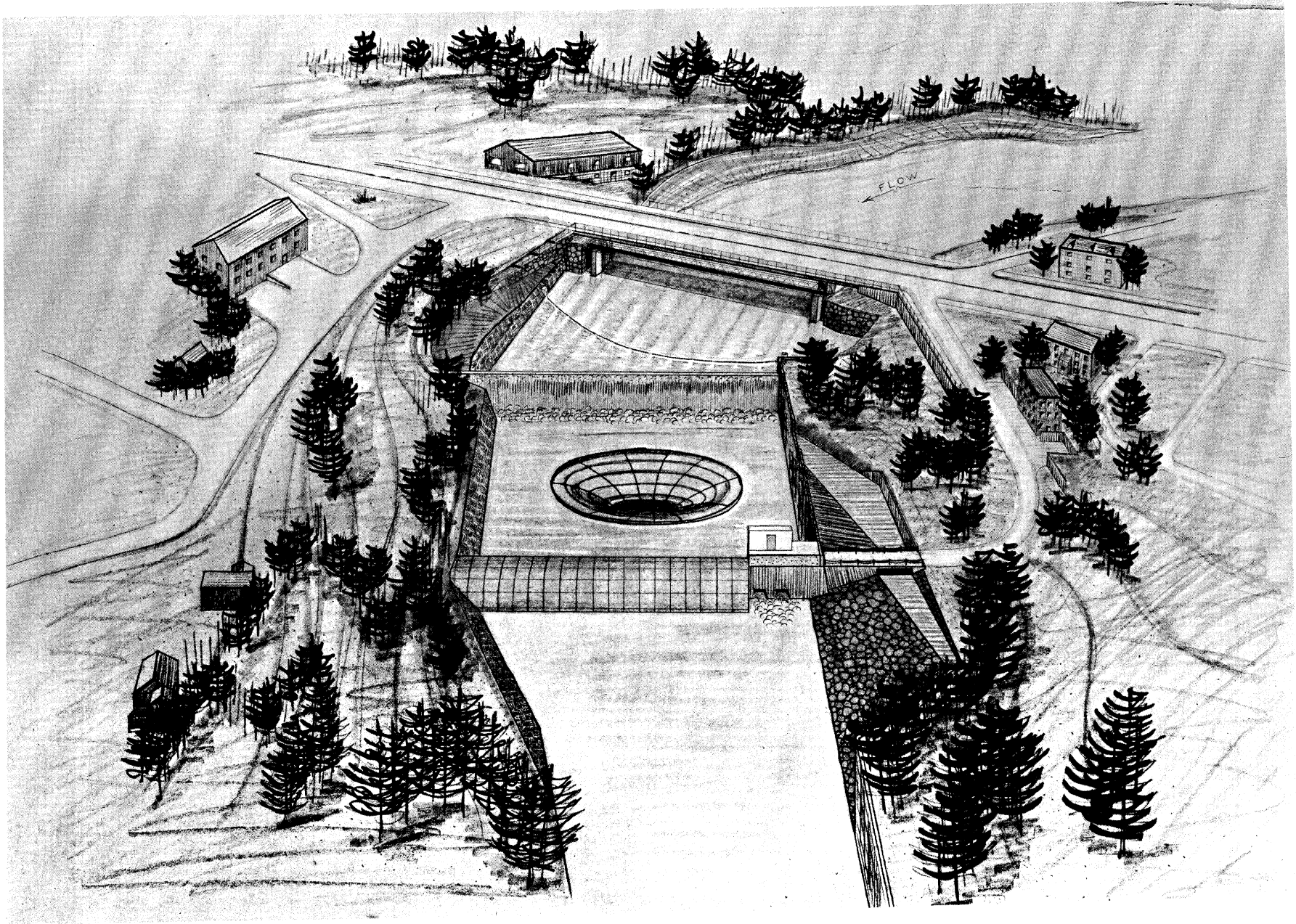




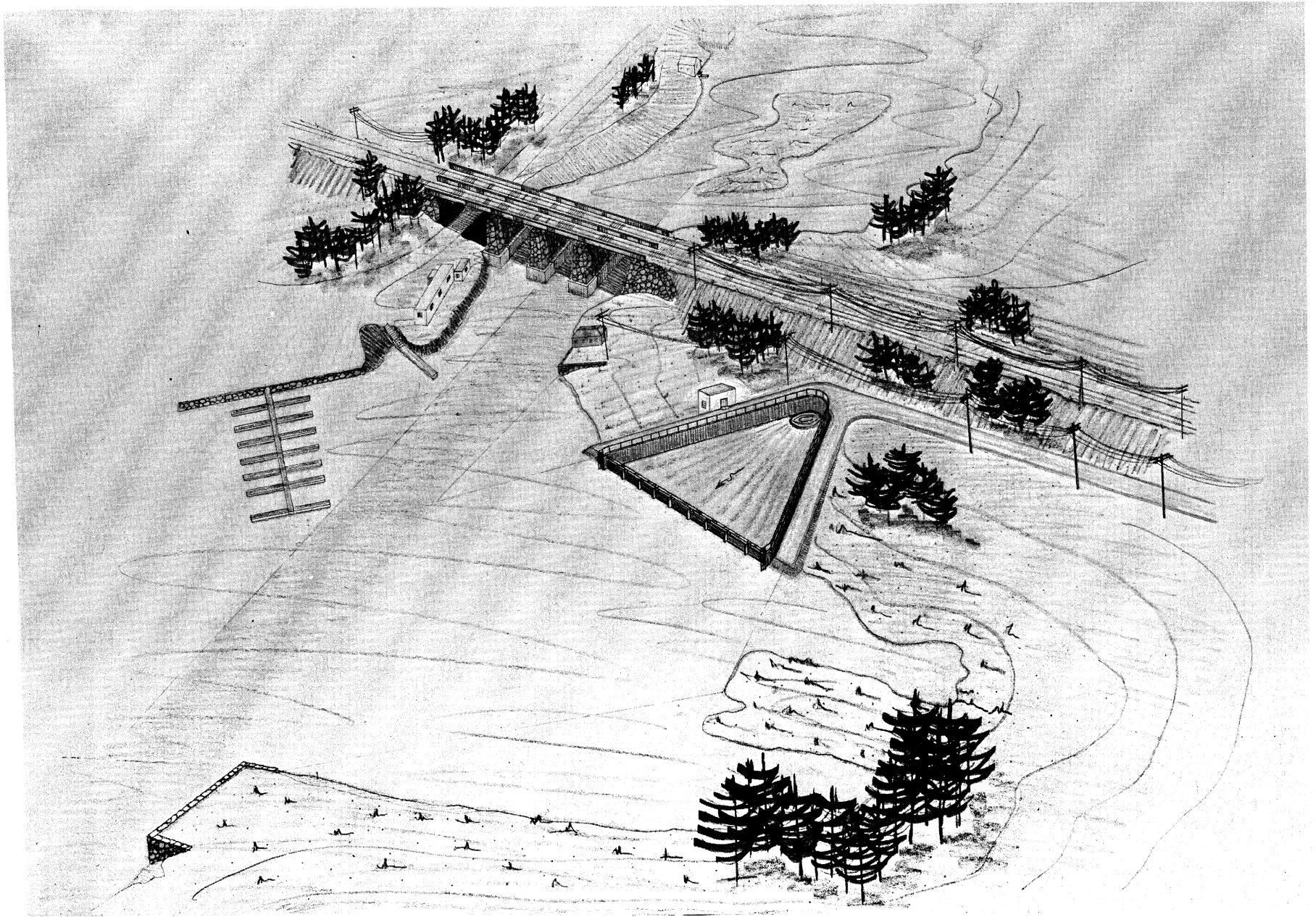
NOTE
Plan from U.S.G.S.
(photo revised) 1970 Quadrangle map



WATER RESOURCES MANAGEMENT REPORT
PAWTUXET RIVER BASIN
RHODE ISLAND
NATICK DIVERSION
GENERAL PLAN AND PROFILE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.



NATICK DIVERSION INTAKE WORKS



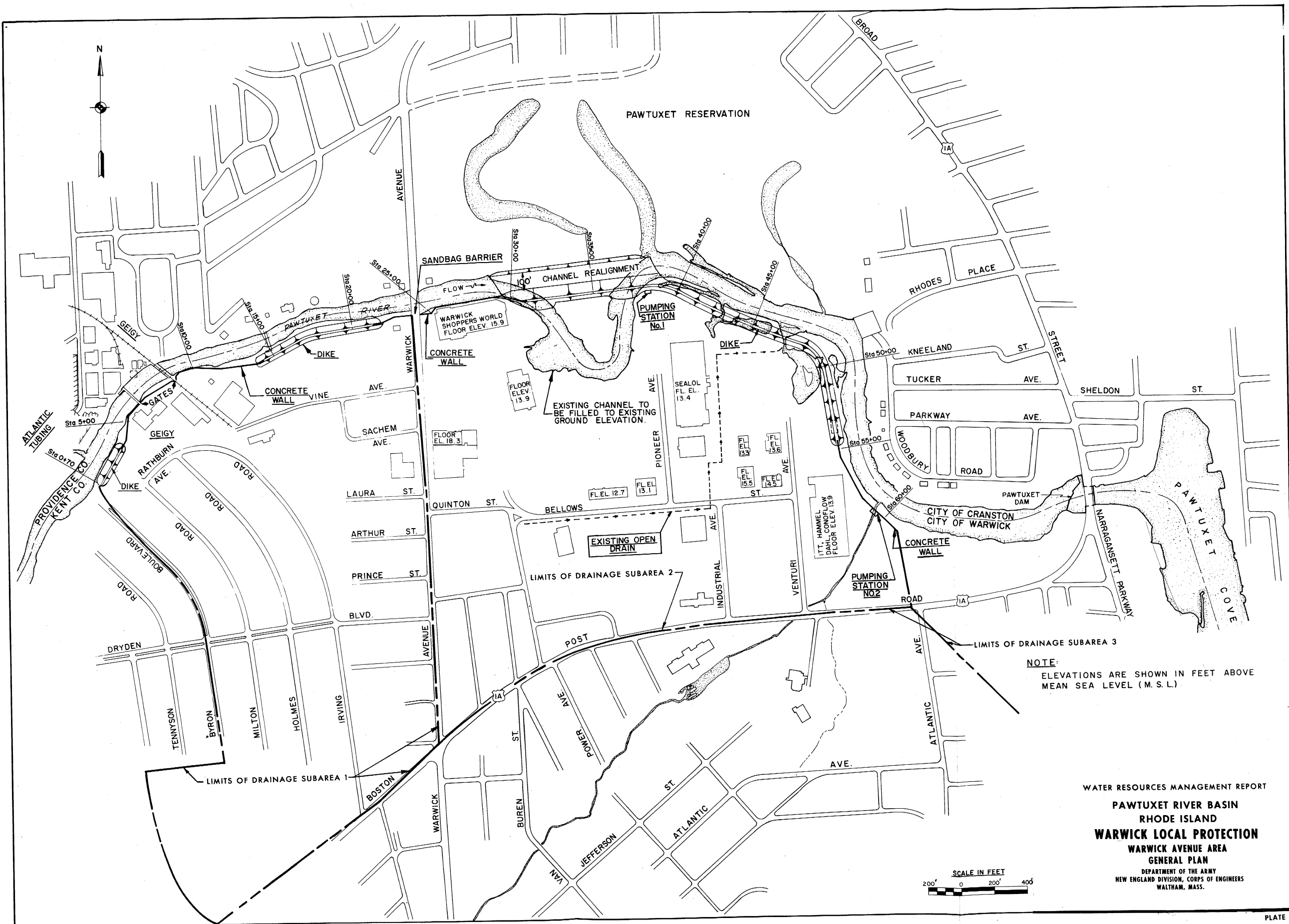
NATICK DIVERSION OUTLET WORKS

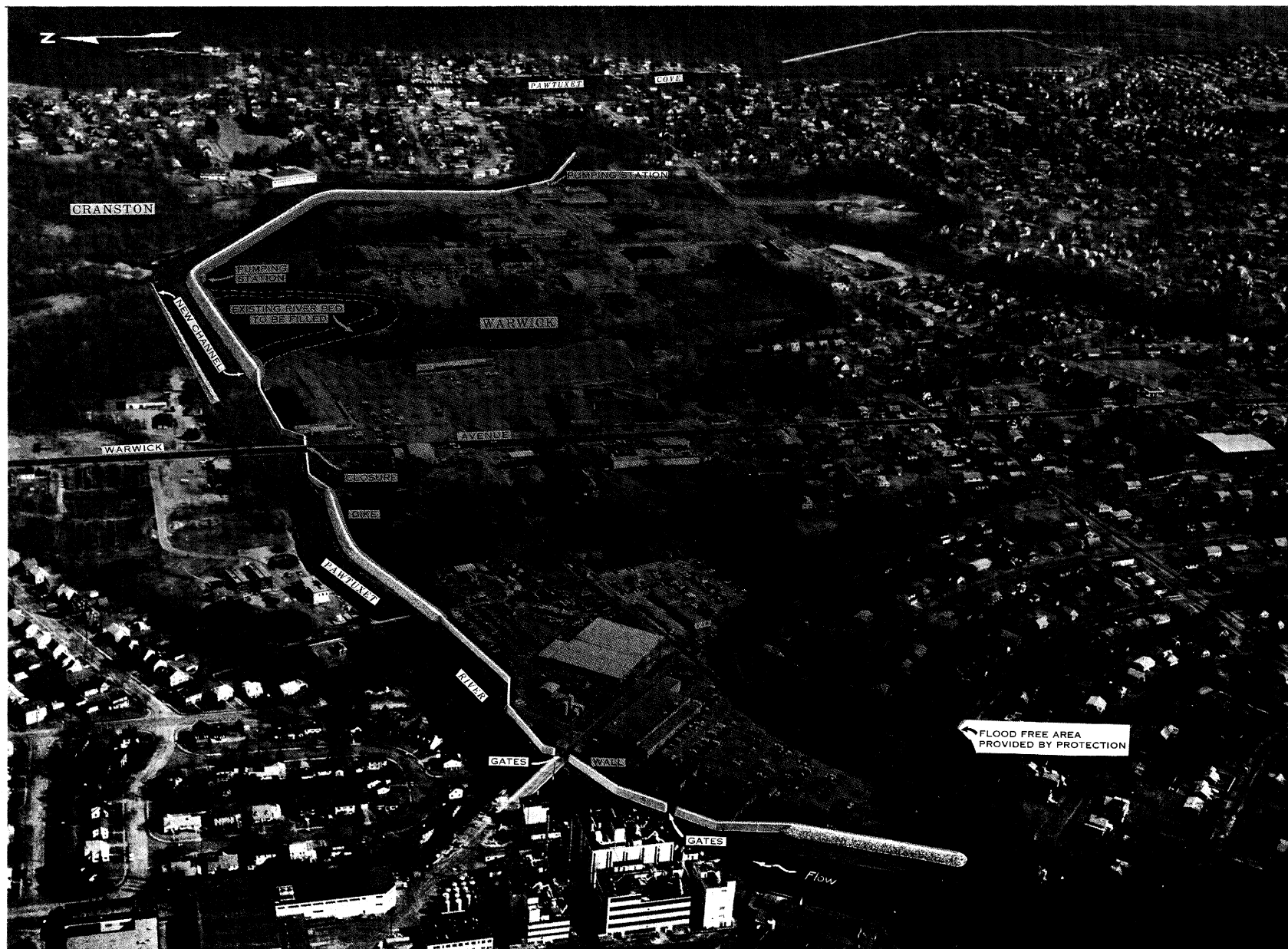
WARWICK LOCAL PROTECTION

CAPTION

The following plans on Plates 5 and 6 together with the annotated aerial photographs clearly show the locations of the dikes and walls proposed in the plan for construction of the Local Protection Project in Warwick. The areas shaded in blue represent those protected from flooding by the project.







WARWICK LOCAL PROTECTION - Warwick Avenue Area



WARWICK LOCAL PROTECTION - Elmwood Avenue Area

**WATER LEVELS ALONG MAIN STEM
UNDER VARIOUS FLOOD CONDITIONS**

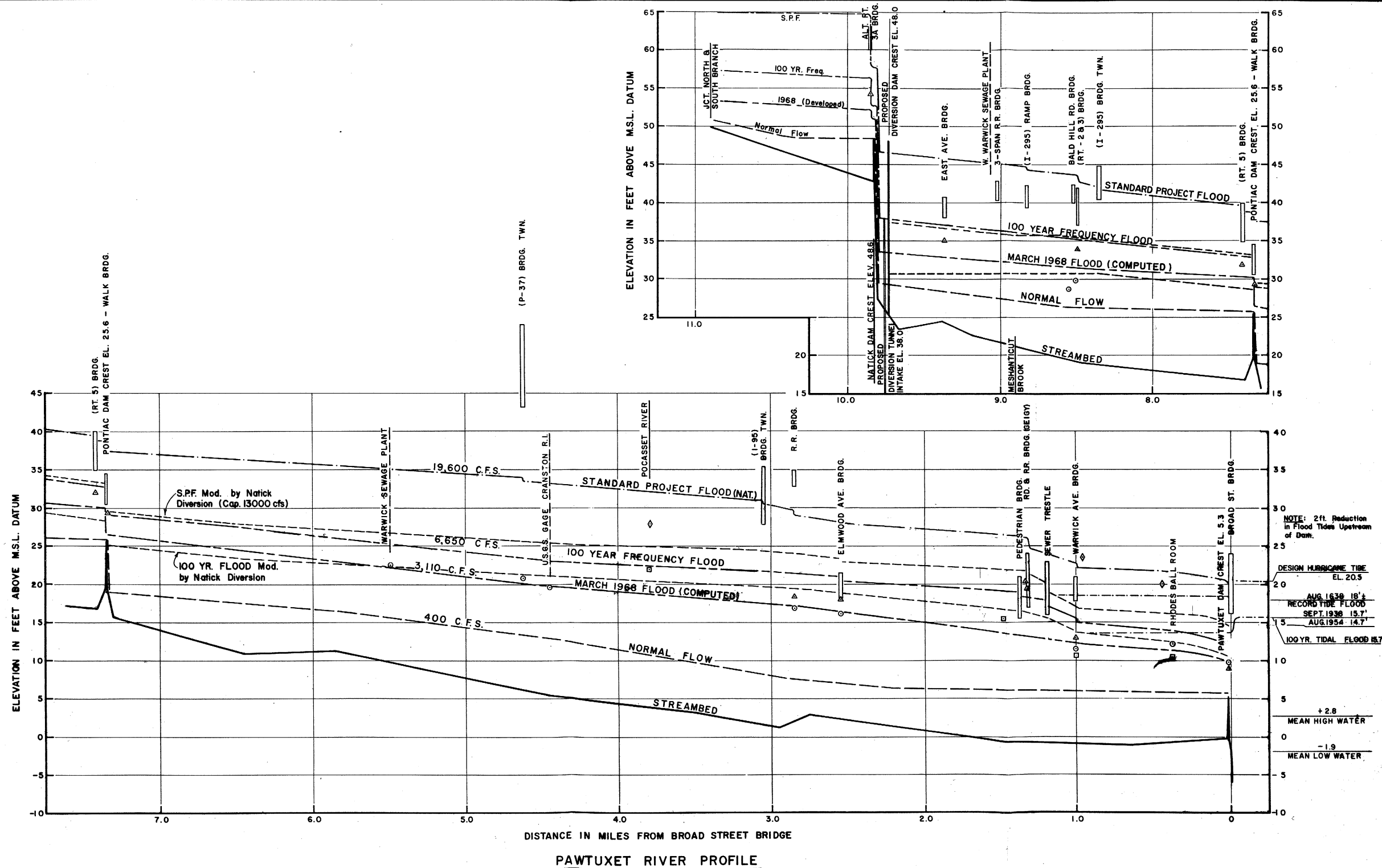
CAPTION

The last significant flood on the Pawtuxet occurred in March, 1968. It caused moderate damage in Warwick Industrial Park at the lower end of the main stem. Such a flood has an average probability of occurrence of once every 15 years.

A 100-year flood -- An event having a one percent chance of occurrence in any given year -- would cause water levels averaging four feet higher than the March, 1968 flood.

A Standard Project Flood (SPF) -- representing the flood discharge that could be expected from the most severe combination of weather, run-off, and reservoir storage conditions considered reasonably characteristic of the region -- would cause water levels averaging eight feet above the 100-year flood and 12 feet higher than the March, 1968 flood. Such an SPF flood would cause catastrophic damages running into the millions of dollars and probably result in injury and loss of life, as well.





WATER RESOURCES MANAGEMENT REPORT
PAWTUXET RIVER BASIN
RHODE ISLAND
FLOOD PROFILES - MAIN STEM
 DEPARTMENT OF THE ARMY
 NEW ENGLAND DIVISION, CORPS OF ENGINEERS
 WALTHAM, MASS.